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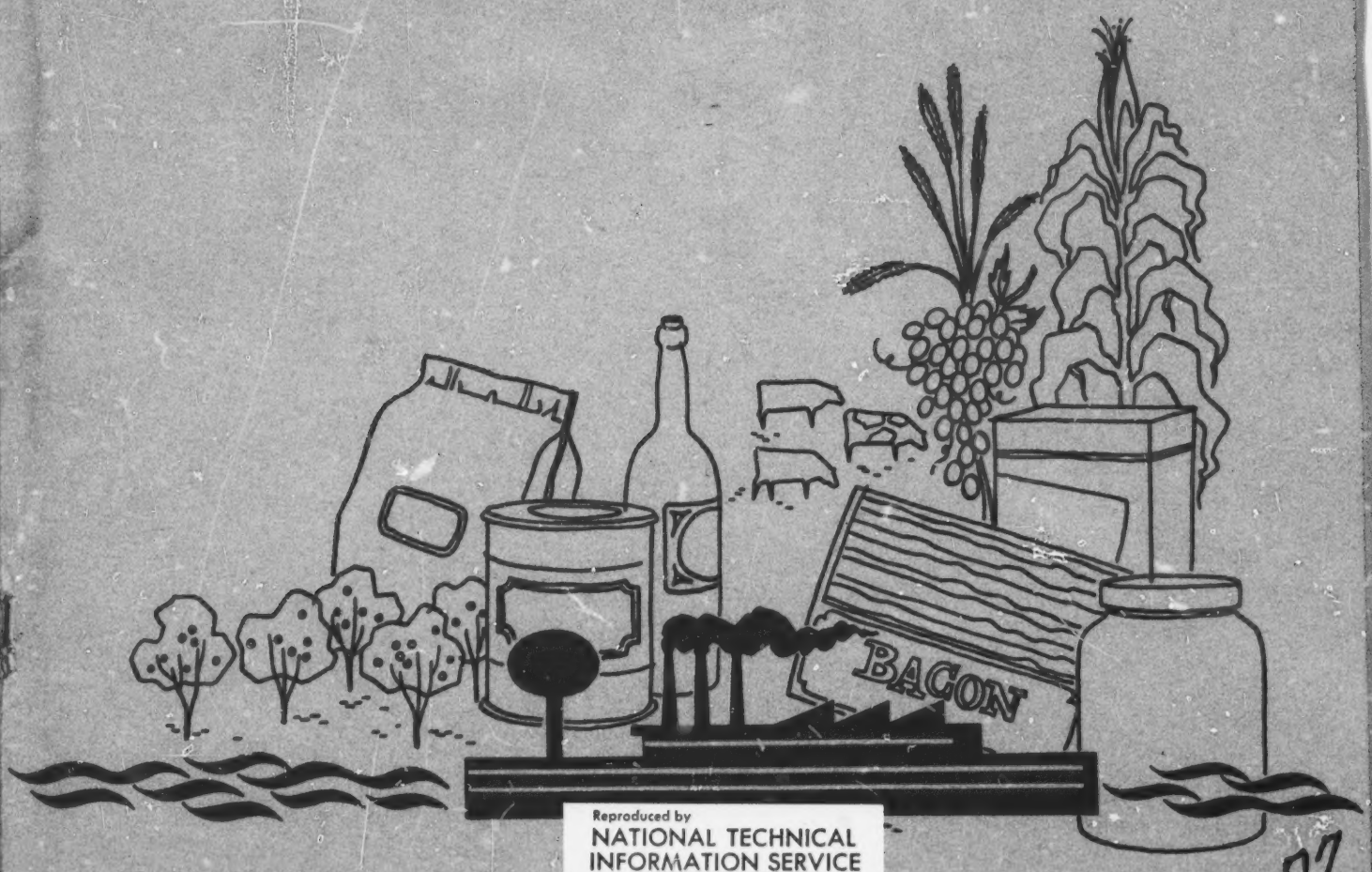
Reconditioning of Food Processing Brines



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Reconditioning of Food Processing Brines

by

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Berkeley, California 94710

for the

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ABSTRACT

Storage brines and processing waters from the production of canned ripe olives and glass packed green olives were treated with activated carbon. The reuse potential of reconditioned brines was evaluated. Reconditioned storage brines can be used to store freshly harvested olives for commercially significant periods. Canned samples prepared from olives stored in reconditioned brine were of good quality. Reconditioned brines of lower salt content were reused with no detectable effect on the quality of the final product.

Estimates for commercial application of activated carbon treatment of storage brines show a cost per ton of olives stored of $3.64 when capital costs are amortized over 10 years for a cannery storing 5,000 tons of olives annually. This value can also be expressed as a cost of $36.40 for each 1,000 gallons of reconditioned brine produced. Ten olive canneries reconditioning brine and sending spent carbon to a centrally located reactivation facility would have a cost of $1.28 per ton of olives stored or $12.80 for each 1,000 gallons of reconditioned brine produced.

This report was submitted in fulfillment of Grant 12060 EHU under the partial sponsorship of the Federal Water Quality Administration.

Key Words: Olive brines, brines, canneries, brine disposal, activated carbon, reclaimed water, industrial waste, waste treatment.

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SECTION I

CONCLUSIONS

Strong sodium chloride brines used for storage of olives can be reconditioned and reused on a commercial scale.

The volume of brine which can be reconditioned and reused is 20,000 gal. per ton of fresh activated carbon.

Reconditioned brine can be stored in the absence of freshly harvested olives for six weeks before reuse.

The quality of the final product from processing of olives stored in brine reconditioned by treatment with activated carbon is equivalent to the quality of products from olives stored in virgin brines.

Lower salt content processing waters can be reconditioned for reuse by treatment with activated carbon.

The cost of reconditioning olive storage brines for reuse is estimated at $1.28 per ton of raw olives when capital costs are amortized over a period of ten years and the scale of operation is 50,000 tons of olives per year.

The cost of reconditioning olive storage brines for reuse is estimated at $3.64 per ton of raw olives when capital costs are amortized over a period of ten years and the scale of operation is 5,000 tons of olives per year with a single use of activated carbon.

Activated carbon used for brine reconditioning can be reactivated through at least two cycles with no loss in efficiency.

The color of the reconditioned brine is the best criterion of reuse potential of the five analytical indices (salt content, chemical oxygen demand, pH, color and total acidity) investigated.

SECTION II

RECOMMENDATIONS

The olive canning industry should give serious consideration to activated carbon treatment of storage brines on the basis of placing brine reconditioning units in each processing plant and by operating a centrally located carbon reactivation plant cooperatively. As a second choice alternative, brine reconditioning units should be installed and operated in those plants where the saline pollution potential is most critical; these units to have no reactivation capability. Further research should be conducted on the utility of carbon reconditioning of processing waters to reduce the volume of discharge of these waste materials.

Further research should be conducted on the utilization of reconditioned storage brines as canning brines. A promising use of reconditioned storage brine is as a canning or bottling brine after adjustment of pH and salt content to appropriate levels. The use of reconditioned brine as storage brine would utilize an equivalent amount of salt to that employed in increasing the salt content of storage brines during the period just after addition of freshly harvested olives to storage tanks containing diluted, reconditioned brine.

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SECTION III

INTRODUCTION

The growing and processing of olives for oil and for preservation by canning is a small but substantial part of the California agricultural economy. It has been estimated that there are 32,000 acres of olives grown in California. The annual hand-harvested crop produced by this acreage has a gross value of $15,000,000. The annual gross value of olive products produced in California has been estimated at $40,000,000.

A brief review of the major steps in the production of canned ripe olives will serve to indicate the nature and magnitude of the olive industry's waste disposal problem. Olives are harvested in the late fall period of mid-September to early November. The olives are trucked to processing plants where they are size-graded by diverging cable type graders, usually into five sizes. Because processing cannot keep pace with the harvest, they must be stored in large tanks and processed in salt brines (covered with sodium chloride solution). The concentration of brine used depends on the variety of olive being stored. The brine is generally 4 to 5 percent concentration for Mission, Manzanillo and Barouni varieties and 3 to 4 percent for Sevillano and Ascolano varieties. The concentration of the brine is gradually increased over a period of three to four weeks to a level of 8 to 9 percent for the smaller sized varieties and 7 to 8 percent for the Sevillano and Ascolano varieties.

The majority of the olives are stored in the brine for 1.5 to 6 months. At some plants, Mission and Manzanillo varieties are stored for as long as ten months (in this case the brine concentration is increased to 10 percent).

When olives are to be processed they are transferred from the storage tanks to shallow concrete or wooden vats, which hold about one ton of olives. The olives are treated with three to eight changes of dilute sodium hydroxide (lye) solutions. The first lye is usually 1 to 1.5 percent in concentration and the subsequent solutions are 0.5 to 1 percent concentration. Between applications, which usually last for 1.5 to 3 hr, the olives are covered with water which is vigorously aerated by compressed air, or the drained olives are exposed to air for 4 to 24 hr. The object of the

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lye treatment of olives is to hydrolyze the bitter principle (oleuropein). The aeration at slight alkalinity oxidizes the tannins and causes the olives to develop a black color. The olives are washed with a number of changes of water until they are practically free of sodium hydroxide (pH 7.3 to 7.8). The washed olives are stored for 1 to 2 days in 2.5 percent brine before they are size-graded a second time and sorted.

The olives are canned in enamel-lined cans using a hot 2.5 to 3 percent sodium chloride solution to fill the can to the desired headspace level. The brine frequently contains up to 3 oz of ferrous gluconate for each thirty gal. of brine to fix the color of the canned olives. The cans are generally closed in a steam flow type double seamer to achieve a good level of vacuum after retorting and cooling. The sealed cans are placed in retort cars or baskets and heated in closed retorts at 240°F for one hr. The cans are cooled with cold potable water and then dried, labeled and cased.

The popularity of pitted olives is increasing and at present accounts for a substantial fraction of the total production. The olives are pitted after curing and the second size grading stage. Two different makes of machines align the olives in a vertical position. A coring tube produces a loose cylindrical section of pit and flesh. A punch pin moves in from the opposite side from the coring tube to push out the pit segment. These pitting machines have a capacity of about 800 olives per min.

Green ripe olives are prepared from fruit taken directly from the tree. The olives are treated with two lye solutions, the first for about 18 hr and the second for 24 hr. The olives are washed with three changes of water each day for three days. The washed olives are treated with 3 percent sodium chloride solution for two days, with 3 to 4 changes of the brine. The olives are then size-graded and sorted. The remainder of the operation is identical to that of the canned, black, ripe olives.

The third type of preserved olives (packed in glass jars) are the Spanish green type product. These olives are prepared from full sized fruit of the smaller sizes of Manzanillo or Sevillano variety. The green colored fruit is treated in shallow tanks with 1.5 to 2 percent sodium hydroxide until the lye has penetrated to a depth of one-half to two thirds of the space between the skin and the pit. The olives are then washed with cold water for 12 to 24 hr until almost

all of the lye is removed. The water changes are made with minimum contact of the olives with air to avoid darkening of skin color. The washed olives are placed in 50 to 60 gal. oak barrels which are filled with strong sodium chloride solutions (5 to 6 percent for Sevillano and 12 to 15 percent for Manzanillo). The barrels containing Sevillano olives are treated with rock salt until the concentration reaches 7 to 8 percent. The olives undergo bacterial fermentation which produces lactic acid. The fermentation proceeds over a period of 60 to 120 days. The acid acts as a preservative and with other fermentation-produced compounds imparts the characteristic flavor of the Spanish-type olive. When the olives have developed the desired color, flavor and acidity (about 1 percent total and at a pH of 3.8), they are drained of brine, size-graded mechanically and sorted on slowly moving belts. The Spanish olives are packed in jars by hand, rinsed with water in the jars by machine and filled with 7 percent sodium chloride solution before capping.

It is obvious from the above outline of olive processing methods that the spent brines and alkaline solutions constitute a considerable volume of strong wastes. It has been estimated that nine olive companies in the Central Valley used 4,300,000 lb of sodium chloride and 740,000 lb of sodium hydroxide to preserve 21,000 tons of olives in the 1961-62 season. Some 226 million gallons of water were discharged during these operations. A simple calculation shows that the ratio of sodium chloride used divided by the volume of water discharged would give a level of 2300 ppm of sodium chloride as the average concentration in discharge water.

The Central Valley Water Quality Control Board passed resolutions in 1963 which establish discharge requirements for most of the olive processors in the San Joaquin Valley. In substance, the resolutions say that if waste waters from any processing operation are discharged in such a way that pollution of stream or ground water would occur, the salt content must not be more than 175 ppm.

Substantial quantities of sodium salts (chloride, hydroxide) are used in many food processing operations. The disposal of the saline liquid wastes from these operations, without causing water pollution, is a problem of increasing complexity. The primary difficulty in the disposal of saline liquid wastes is the non-biodegradable character of sodium chloride and sodium hydroxide. The only economical "solution" to the disposal of saline liquid wastes at present is the

discharge to salt water receiving bodies or dilution with large volumes of fresh water. Many food processors at inland locations have inadequate fresh water dilution capacity available to assimilate discharges of saline liquid wastes from their operations. These food processors must change their production methods and/or disposal practices to reduce the discharge of saline wastes in order to meet water quality standards.

The work described in this report is confined to the treatment and re-use of brines generated during the production of canned olives. The preserved olive industry was selected for this initial study due to the urgent need for ways to alleviate the critical pollution potential of saline liquid wastes discharged from canning plants in the Central Valley of California. Substantial quantities of salt are also used in the production of pickles, sauerkraut and other foods in many areas of the United States. Information developed in this demonstration grant should be useful in the solution of potential water pollution problems of all sectors of the food processing industry which use brines in direct contact with food materials.

Increased total saline loads from population growth and changes in agricultural practices, as well as more stringent discharge requirements, are responsible for the critical disposal problem in the Central Valley of California. Long range research has been underway for several years (at the University of California, Davis and at the National Canners Association Western Research Laboratory) to develop storage systems for freshly harvested olives which do not contain appreciable quantities of sodium chloride. These systems (acidified water containing bacteriostatic organic compounds; chemical fertilizer salt solutions; or controlled atmosphere and temperature storage) would produce waste streams which could be disposed of more readily than sodium chloride brines. This research is in an exploratory or developmental stage and, even if successful, would require five to ten years to become the general commercial practice of the olive canning industry. Until these methods are fully developed and tested on a commercial scale, it will be necessary to reuse or to dispose of strong saline brines in a way which will insure that water quality standards are met.

The existing technology for handling and disposal of food processing brines was reviewed and evaluated in 1967 by the NCA Staff. The most promising method for the immediate relief of saline pollution

problems was concluded to be based on exploratory research done at the Western Utilization Research and Development Division, USDA. Small volumes of spent olive storage brines were passed through a column containing activated carbon. The purified brine was used successfully by a commercial canner to store freshly harvested olives. The final canned product from olives stored in the reconditioned brine was of acceptable quality. The high-lights of this exploratory study have been published (1).

Further developmental work on the use of activated carbon for reconditioning olive brines was reported from the USDA (2, 3). The major objectives of this project were the preparation on a commercial scale of reconditioned olive storage and processing brines and evaluation of their reuse potential.

The reuse potential of reconditioned brines was to be established by direct observation of the results of reuse on the quality of the final, canned, olive product. A set of conventional measurements on the brine samples was selected as indicators of gross changes in brine composition after various treatments and re-use applications. The analyses were of the type that could be done readily in a cannery to serve as a quality control tool or as an indication of the suitability of reconditioned brines for reuse.

The composition of storage brines and processing waters is different for each individual olive canning plant. Different varieties of olives (the four principal varieties are Mission, Manzanillo, Sevillano and Ascolano) require different strengths of brine to avoid skin shrivel problems during storage. Certain plants in the olive industry use low salt content brines, fortified with lactic acid, to store olives. To obtain representative operational experience the brine reconditioning unit was installed at four different locations during the demonstration grant period.

The economics of reconditioning olive brines by activated carbon treatment appeared attractive based on figures derived from small scale studies. The larger scale operations described in this report were necessary to demonstrate technical feasibility on a commercial scale as well as to develop more accurate cost figures.

A storage system for olives has been under investigation since 1966 by Vaughn and co-workers at the University of California, Davis (4).

The storage solution contains no added sodium chloride and depends on a mixture of lactic acid, acetic acid, benzoic acid (and, in some cases, sorbic acid) and anaerobic conditions to control the multiplication of undesirable bacteria and yeast. The system has been used successfully in the production of commercial lots of Sevillano olives, but with other varieties an undesirable softening of the product has been noted.

SECTION IV

DESIGN PHASE

The activated carbon treatment unit used in exploratory studies of brine reconditioning by the USDA in Albany, California was a vertical glass tube 2 in. in diameter (i.d.) and 16 ft in length. The contact time was 50 min with a flow rate of 1 gpm/ft^2 of carbon bed area. The fresh carbon feed rate was 0.40 lb/100 gal. of brine. The unit was operated with the fresh carbon contacting the partially treated brine counterflow operation. The design of the pilot scale brine reconditioning unit was based on the following requirements:

Flow rate:	0.36 to 2.5 gpm/ft^2
Capacity:	30 to 210 gph
Contact time:	15 to 100 min
Fresh carbon feed rate:	0 to 250 lbs/hr

The design developed to meet the above requirements had the following specifications:

Main carbon column volume:	28 ft^3
Main carbon column diameter:	16 in.
Main carbon column height:	20 ft
Carbon slurry feed tank volume:	8 ft^3
Pressure vessel volume:	4 ft^3
Operating pressure of blow case:	50 lbs/in.^{2}
Carbon hopper width:	16 in.
Carbon hopper height:	63 in.

The original design for the pilot scale unit was made by the USDA. Near the start of the project, it was found that severe corrosion occurred in stainless steel equipment exposed to mixtures of carbon and salt brine. It was necessary to convert the original drawings which had specified stainless steel as the material of construction to drawings based on fiber glass reinforced food grade resin. A company manufacturing plastic equipment provided a set of drawings which served to obtain bids from potential suppliers of the pilot scale brine reconditioning unit.

SECTION V

CONSTRUCTION PHASE

The California Blow-Pipe and Steel Company of Escalon was selected as the primary contractor. The sub-contractor for the fabrication of the plastic components was the Heil Process Equipment Corporation of Cleveland, Ohio. Working drawings for the plastic components and the steel support structure were prepared, reviewed and modified before construction began.

The plastic components were fabricated in Houston, Texas and shipped to Escalon where they were mounted in the steel support structures. One section of the support structure housed the main column section, the carbon addition hopper and the spent carbon drain section. A second support section housed the carbon feed tank and the blow case. The major components of the brine reconditioning unit were transported horizontally on a 40 ft flat bed truck. At the site a crane lifted the sections from the truck and placed them in the normal (vertical) operating position. The support structure and enclosed sections were secured with four guy lines.

A 1500 gal. capacity plastic swimming pool served as an influent brine settling tank. Brine was delivered from the settling tank (through a stainless steel cloth filter) with a Moyno pump (Model Number 1 L 3 SSQ) rated at 0.5 to 3.5 gpm. The brine was pumped to the bottom of the carbon column through a hose line and distributed with a circular, perforated stainless steel pipe.

Compressed air was supplied by a 1 horsepower air compressor (Ingersoll-Rand Model 1 HPC1) at 50 lb pressure. A control panel having a manifold of pressure regulators and valves was used to control air pressure to the blow case and to the air activated valves. Copper tubing was used to deliver compressed air to the Keystone valves. An open plastic tank was provided for preparation of carbon-water slurries.

The overflow return from the hopper to the slurry tank was transported through a 2 in. polyvinyl chloride pipe. The carbon was held in the column by polyethylene beads and stainless steel cloth. The effluent brine was delivered to collecting tanks through a 1 in. hose. Sampling ports on the side of the main column spaced 2 ft

apart starting 4 ft up from the bottom end of the column (number 1 for the lowest and 5 for the highest) were used to collect samples representative of brine at various levels in the carbon bed. A schematic drawing of the major components of the brine reconditioning unit is shown in Figure 1.

Figures 2 through 4 show the final assembled unit as it appeared on location in Lindsay. Figure 2 shows an overall view of the unit and accessory equipment. Figure 3 was taken at ground level and shows the air compressor, delivery pump and influent brine tank in the left background. Figure 4 is of the carbon slurry preparation tank and pressure blow case.

All necessary accessory components (air compressor, delivery pump, piping, guy cable and turnbuckles, compressed air reduction manifold and control panel, activated carbon, plastic float screen and filter cloth) were purchased and delivered to Lindsay, California where the unit was located initially.

The brine reconditioning unit and accessories had a total capital cost of $15,000. The unit had an activated carbon capacity of 1000 lb.

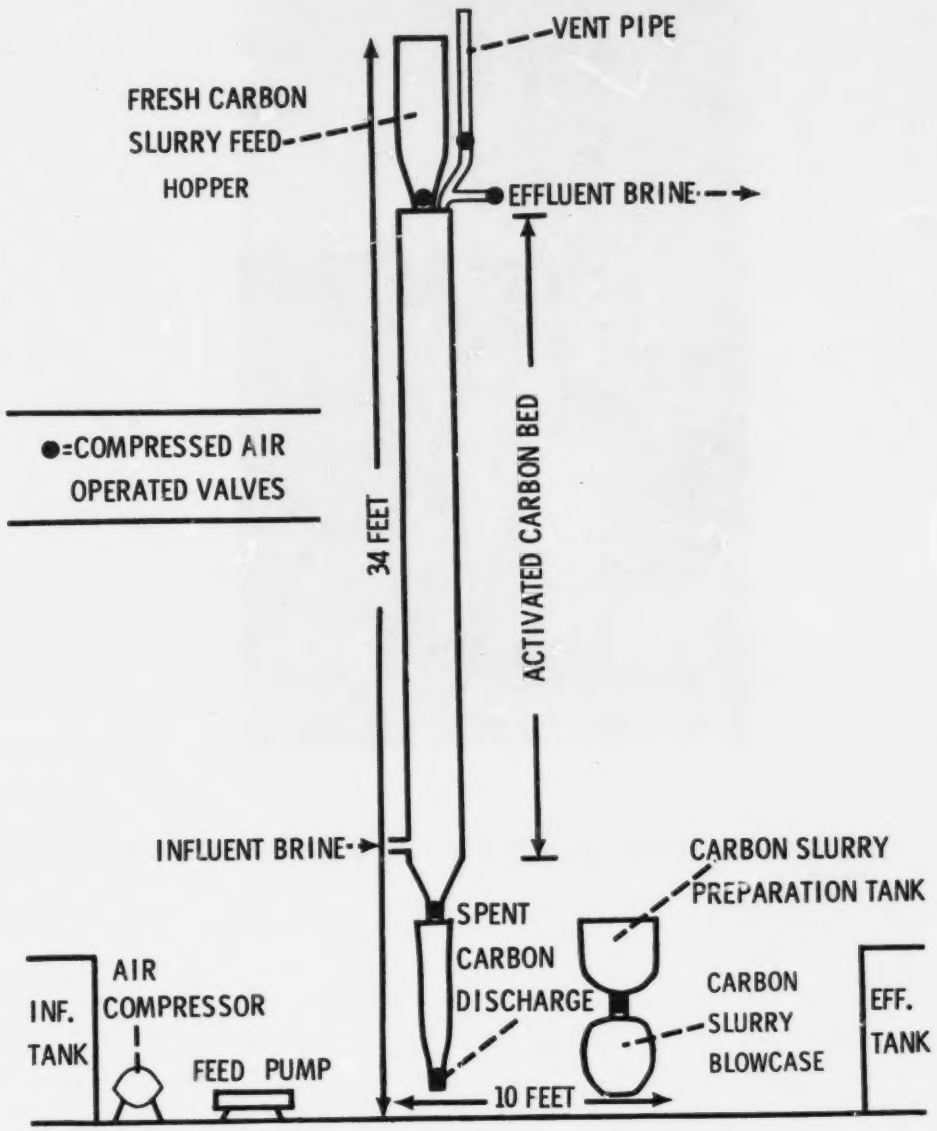

FIGURE 1 SCHEMATIC DRAWING OF BRINE RECONDITIONING UNIT
(NOT TO SCALE)

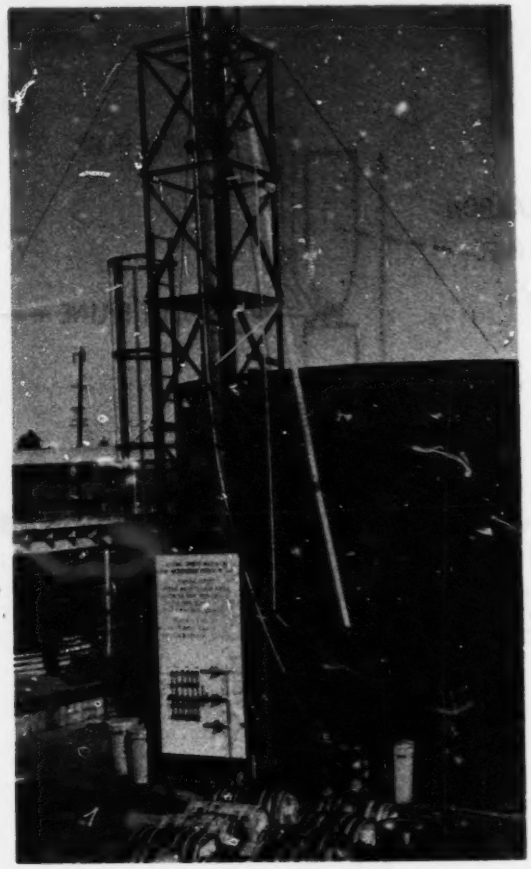

FIGURE 2. OVERALL VIEW OF BRINE RECONDITIONING UNIT

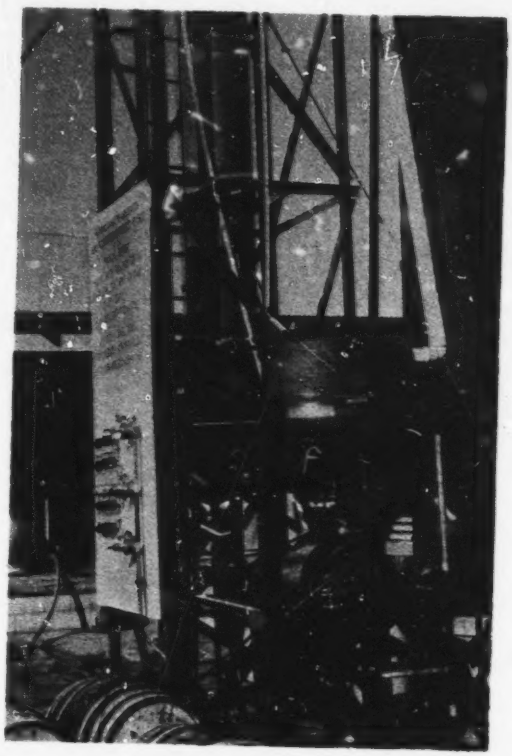

FIGURE 3.
LOWER PORTION OF BRINE RECONDITIONING UNIT WITH ACCESSORY COMPONENTS IN BACKGROUND

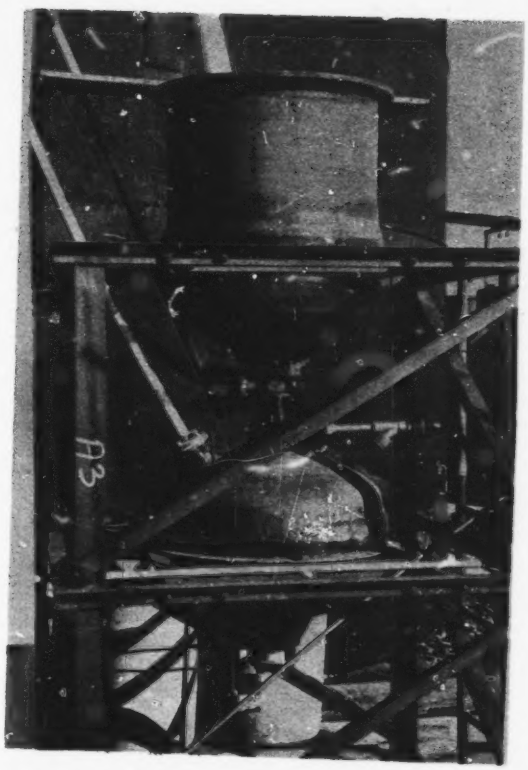

FIGURE 4.
CARBON SLURRY TANK AND BLOW CASE

SECTION VI

OPERATIONAL AND EVALUATION PHASE

A number of problem areas were investigated during the operational phase of the project. The brine reconditioning unit was operated at four locations in California for the reasons stated in the Introduction. The major problem areas studied during the operational phase were: treatment of storage brines of various composition, treatment of processing waters, analytical indicator of reuse potential, carbon reactivation and reuse potential, quality of brines produced, and estimation of the cost of the process on a commercial scale. The problem areas investigated are tabulated in Table I along with a listing of the site of each investigation and a reference to the section of the report where observations are recorded or results are described.

Table I

PROBLEM AREAS INVESTIGATED
DURING OPERATION OF BRINE RECONDITIONING
UNIT AT FOUR LOCATIONS

Location	Problems Investigated	Text Reference
Lindsay	Treatment High Salt Content, Medium B.O.D. Content Storage Brine	Table II
	Storage of Olives in Reconditioned Brines	Page 37
	Storage of Reconditioned Brine in Absence of Olives	Page 36
Visalia	Treatment of Low Salt Content, High Lactic Acid Content Storage Brines	Table III
	Treatment of Imported Spanish Olive Brine	Table VIII
	Treatment of Olive Processing Waters	Tables IX, X, XI

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Location	Problems Investigated	Text Reference
Madera	Treatment of Storage Brine For Storage Experiments	Table IV
	Treatment of High B.O.D. Content, Salt-Free Storage Brines	Table V
	Treatment of High B.O.D. Content, High Salt Content Storage Brines After Carbon Conditioning With Salt Free Storage Brine	Table VI
Oroville	Continuous Operation of Unit With High B.O.D. Content, Medium Salt Content Storage Brine	Table VII
	Carbon Regeneration Tests	Tables XII, XIII
	Evaluation of Activity of Furnace Regenerated Carbons	Tables XIV, XV, XVI
	Iron Content in Carbon Treated Storage Brines	Appendix
	Storage of Olives in Brines Receiving Various Extent of Treatment	Table XVII
	Determination of Usefulness of Analytical Measurements in Predicting Brine Quality	Page 44
	Development of Values for Cost Estimates	Table XX

Treatment of Storage Brines

The brine reconditioning unit was used first in Lindsay, California (starting in September, 1968) to process high salt content olive storage brines which had been used on olives stored during the 1967 season. The column section of the unit was charged with 1000 lb of CAL Type 12 x 40 activated carbon (Pittsburgh Activated Carbon Company, Calgon Corporation) by making a water slurry of the carbon in the feed tank, delivering the slurry to the blow case, and immediately forcing the slurry with compressed air to the carbon slurry hopper at the top of the column. The only operational problem encountered with the unit occurred when carbon settled out of suspension and deposited in the lower region of the blow case, restricting carbon delivery to the top of the column. It was possible to mix separated carbon slurries using pulses of compressed air in the blow case before sustained pressure was applied to force the slurry to the hopper at the top of the column.

The influent brine was delivered to a plastic swimming pool to allow larger sized suspended material to settle out. The intake pipe to the delivery pump was covered with 400 mesh stainless steel hardware cloth to remove finely divided suspended solids.

In the initial experiments, an influent flow rate of 2 - 3 gpm was used. Later experiments used lower flow rates to utilize the carbon adsorption capacity more completely by increasing the contact time.

The following analyses were performed on as many representative samples of brine and processing water as time and availability of trained personnel allowed: 1) Chemical oxygen demand (C.O.D.); 2) Suspended solids (SS); 3) Color; 4) pH; 5) Total acidity; and 6) Salt content. The C.O.D. method was that described by Jeris (5) and while this method is not considered a Standard Method it gave good agreement with C.O.D. values determined by the Standard Method on identical samples.

It was expected that one or a combination of the analyses listed above would correlate well with the reuse potential of reconditioned olive brines. The experimental details for the analyses listed above will be found in an Appendix to this report.

Numerous samples were taken during the operation of the brine reconditioning unit from the various sampling ports. Analysis of these samples showed consistent trends in the variables with depth of carbon.

The analysis for color is typical of the results obtained in a series of samples taken from the five sampling ports over a period of ten minutes. A representation of the strip chart recording of the visible light absorption spectra as a continuous trace for a series of brine samples is shown in Figure 5. In general all analyses made of samples taken from the sampling ports showed gradients similar to the color analysis represented by Figure 5. For this reason results from port sampling are generally omitted from the tabulated data in this report and are listed in the Appendix.

A total of 12,750 gal. of storage brine was put through the unit over a period of fourteen days of intermittent operation. The flow rate was from 2 to 3 gpm. Six 60-lb portions of fresh carbon were added at intervals during this period after spent carbon had been removed. Samples of influent brine, brine at various sampling ports on the column and effluent brine were collected and analyzed. The observations and analyses made during this period are tabulated in Table II and in the Appendix.

A total of 10,000 gal. of low salt content olive storage brine was processed with the activated carbon column at Visalia. The flow rate through the carbon bed was maintained at 1.25 gpm. The influent brine came from two separate 5000 gal. storage tanks. The results of measurements on the treated brine from these tanks are tabulated in Table III.

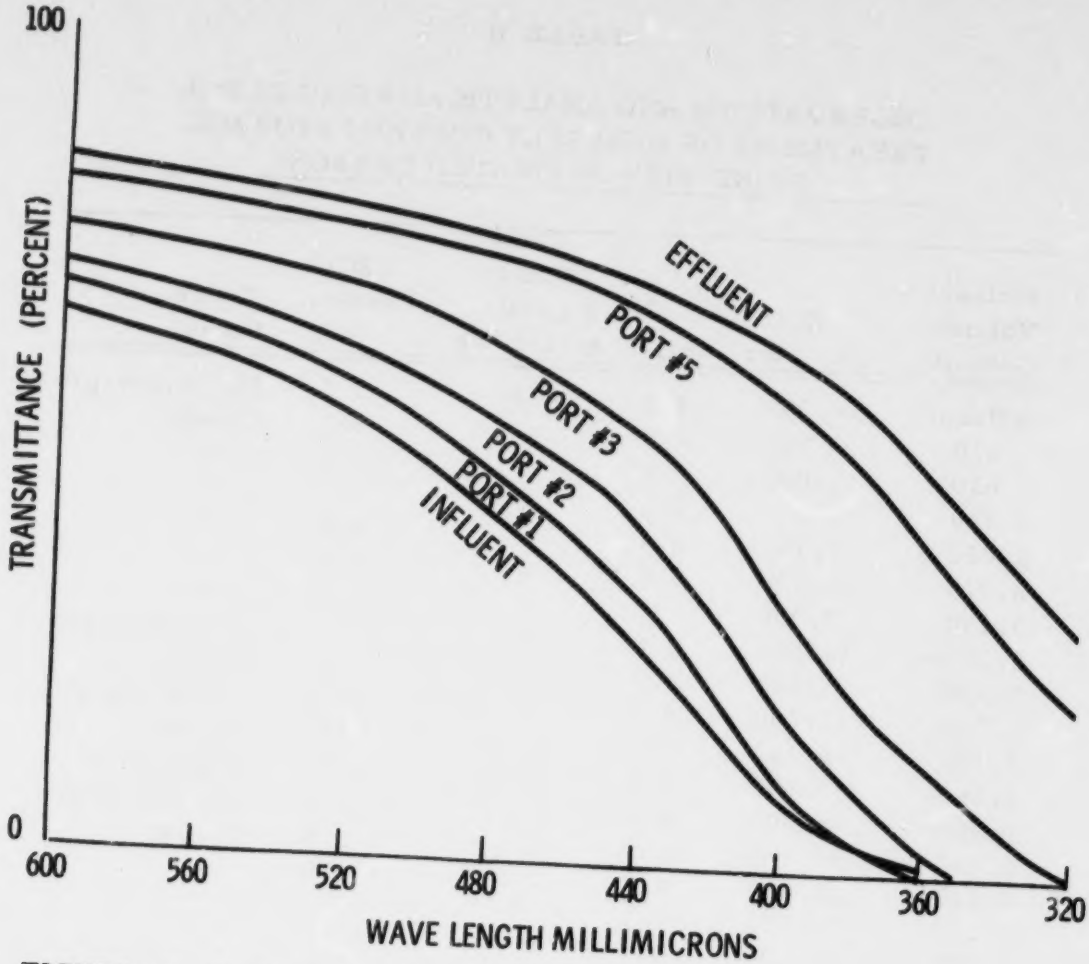

FIGURE 5. PLOT OF ABSORPTION SPECTRA OF OLIVE BRINE SAMPLES

TABLE II

OBSERVATIONS AND ANALYTICAL RESULTS FOR TREATMENT OF HIGH SALT CONTENT STORAGE BRINE WITH ACTIVATED CARBON

Effluent Volume, Gallons	C.O.D., mg/liter	pH	Total Acidity, g Lactic Acid/100 g	NaCl Content, %	Color, Visual
Influent	18,000	4.3	0.39	5.5	Dk. yellow-grn.
270	800	8.0	*	5.1	Cloudy
630	5,000	6.8	*	5.5	"
1,350	*	7.4	*	"	"
2,010	9,100	5.1	*	5.4	"
2,910	10,200	4.6	*	5.5	"
3,150	9,000	"	*	5.4	"
3,270**	10,500	4.8	*	"	Lt. yellow-grn.
3,390	5,400	6.2	*	"	Cloudy
3,750	11,200	4.5	*	5.5	Lt. yellow-grn.
4,110	12,400	"	0.20	"	Cloudy
4,660	10,700	4.2	0.32	"	Light grey
Influent	16,800	4.2	0.35	6.2	Dk. yellow-grn.
5,630	10,400	4.3	0.31	5.8	Cloudy
5,930	11,400	4.0	0.37	6.0	"
6,230	10,700	4.3	"	"	"
7,175	13,100	4.2	0.38	"	"
7,200**	14,800	4.4	0.21	6.2	"
7,775	6,600	6.7	0.01	"	Light grey
8,075	11,100	4.2	0.35	"	Cloudy
8,375	11,400	"	0.38	"	"
8,400	7,900	4.5	0.14	6.0	"
8,700	10,800	3.9	0.37	"	"
9,000	17,800	4.1	0.38	"	"
9,150	13,100	4.0	"	"	Light grey
9,650	*	"	"	*	Cloudy
9,800**	*	3.9	0.41	*	"
10,985**	6,600	7.1	0.03	5.6	Light grey
Influent	18,900	4.1	0.41	6.0	Dk. yellow-grn.
11,225	11,300	4.2	0.42	5.6	Cloudy
12,105	19,000	4.4	0.48	*	Lt. yellow-grn.
12,750	18,900	4.1	0.41	*	"

*Not measured.

**60 lb of fresh carbon added.

TABLE III

OBSERVATIONS AND ANALYTICAL RESULTS FOR TREATMENT OF LOW SALT CONTENT STORAGE BRINE WITH ACTIVATED CARBON

Effluent Volume, Gallons	C.O.D., mg/ liter	SS, mg/ liter	pH	Total Acidity, g Lactic Acid/100 g	NaCl, Content, %	Color, Visual	Light Transmittance, %
Influent	22,300	64	4.0	0.42	1.65	Dk. Brwn	33
834	10,700	98	5.6	0.07	1.45	Colorless	100
1,670	20,500	36	4.2	0.41	1.45	Lt. yellow	"
2,500	21,900	51	4.1	0.42	1.60	"	"
3,340	21,900	51	4.0	"	1.60	"	"
4,170	22,100	28	"	"	1.60	"	"
5,000	22,100	30	"	"	1.65	"	"
Influent	25,200	49	4.1	0.39	2.15	Dk. Brwn	27
5,834	23,800	25	4.0	0.38	1.95	Lt. yellow	100
6,670	22,300	34	4.1	"	2.15	Yellow	90
7,500	21,100	13	"	"	"	"	84
8,340	21,700	33	"	"	"	"	73
9,170	21,500	56	"	0.39	"	"	78
10,000	21,900	79	"	"	2.20	"	88

Initial carbon charge: 180 lb fresh, 820 lb used (See Table II)

After moving the brine reconditioning unit to Madera, the column was filled with 900 lb of fresh carbon. The results obtained during the treatment of 2000 gal. of storage brine at a flow rate of 2 gpm are tabulated in Table IV.

The results of treating salt-free storage brine with activated carbon using a flow rate of 2 gpm are tabulated in Table V. The benzoic acid content was measured during this experiment. The influent brine had 0.126 percent benzoic acid, while a sample taken after 1000 gal. of effluent had been collected showed 0.012 percent benzoic acid.

An additional 4,800 gal. of high salt content storage brine were pumped through the carbon bed with a flow rate of 2 gpm in the Madera final study to determine the effect of the salt-free brine on carbon activity. The results from this experiment are tabulated in Table VI.

TABLE IV

OBSERVATIONS AND ANALYTICAL RESULTS FOR TREATMENT OF STORAGE BRINE FOR STORAGE EXPERIMENTS

Effluent Volume, Gallons	C.O.D., mg/liter	pH	NaCl Content, %	Color, Visual
Influent	25,400	3.7	6.3	Dark purple
400	4,600	8.5	5.2	Colorless
800	14,600	7.2	5.1	"
1,200	18,200	6.0	4.6	"
1,600	27,500	4.0	6.4	"
2,000	25,000	3.8	6.5	"

Initial carbon charge: 900 lb fresh, 100 lb used (See Table XI)

TABLE V

OBSERVATIONS AND ANALYTICAL RESULTS FOR TREATMENT OF SALT-FREE STORAGE BRINE WITH ACTIVATED CARBON

Effluent Volume, Gallons	C.O.D., mg/liter	pH	Total Acidity, g Lactic Acid/100 g	Color, Visual
Influent	45,100	4.1	1.04	Yellow
400	20,600	5.1	0.28	Colorless
800	16,400	4.6	0.73	"
1,200	31,400	4.2	1.25	"

NaCl content was less than 0.1 percent in all samples.

Initial carbon charge: 1000 lb used (See Table IV)

TABLE VI

OBSERVATIONS AND ANALYTICAL RESULTS FOR TREATMENT OF STORAGE BRINE WITH ACTIVATED CARBON CONDITIONED WITH SALT-FREE STORAGE BRINE

Effluent Volume, Gallons	C.O.D., mg/liter	pH	Total Acidity, g Lactic Acid/100 g	NaCl Content, %	Color, Visual	Light Transmittance, %
Influent	19,400	4.8	0.22	7.4	Dk. purple	53**
400	11,500	3.8	0.76	7.8	Milky white	50
800	8,500	4.3	0.35	7.6	"	75
1,200	10,400	4.5	0.31	6.3	"	69
1,600	11,500	4.6	0.32	7.0	"	57
2,000	10,200	4.3	0.27	7.4	Colorless	100
2,400	12,500	4.4	"	8.0	"	100
2,800	12,800	4.7	0.28	7.0	"	100
Influent	31,500	4.7	0.41	6.9	Dk. purple	43**
3,200	25,900	4.5	0.31	7.9	Lt. purple	87
3,600	24,500	4.7	0.28	"	"	91
4,000	20,500	4.6	0.29	"	Med. purple	74
Influent	16,000	4.8	0.27	8.3	Dk. purple	57**
4,400	8,500	4.6	0.10	8.3	Med. purple	81
4,800	7,000	4.5	0.07	8.4	"	80

** Influent samples diluted with five parts of water.
Initial carbon charge: 1000 lb used (See Table V)

The longest periods of continuous operation of the brine reconditioning unit and the largest quantity of brine for a single carbon loading were accomplished at Oroville.

Table VII tabulates the results obtained during the processing of 19,110 gal. of storage brine with a single 1000 lb activated carbon charge. No sampling from individual ports was made during the operations at Oroville. The flow rate was 2 gpm for the first 3510 gal. and then 0.75 gpm until the end of the run at 19,110 gal.

TABLE VII

OBSERVATIONS AND ANALYTICAL RESULTS FOR TREATMENT OF STORAGE BRINE DURING EXTENDED PERIODS OF CONTINUOUS OPERATION

Effluent Volume, Gallons	C.O.D., mg/liter	SS, mg/liter	pH	Total Acidity, g Lactic Acid/100 g	NaCl Content, %	Light Transmittance, %
Influent	39,100	431	4.5	0.48	5.0	1
60	100	7	7.3	0.02	<0.1	97
180	2,300	330	7.9	0.14	4.5	98
420	2,500	333	7.5	0.02	5.3	99
720	13,200	266	6.7	0.05	5.0	86
1,680	23,500	333	5.9	0.11	5.1	77
1,920	23,000	334	"	0.13	4.6	48
3,030	34,500	327	4.4	0.56	4.8	73
3,510	34,100	537	4.6	0.44	5.9	67
3,750	41,500	344	4.5	0.48	4.6	56
4,230	37,000	489	4.4	"	5.6	62
4,470	37,800	424	"	"	4.4	45
4,950	34,100	372	"	0.45	4.6	50
5,190	35,000	469	4.5	"	"	45
Influent	32,500	380	4.3	.49	4.4	15
5,670	35,400	487	4.4	0.46	*	50
6,060	33,700	387	4.5	0.42	3.8	46
9,255	24,000	435	4.3	0.39	*	36
9,615	24,000	389	4.2	0.41	3.6	26
10,335	24,000	395	"	0.39	2.2	27
Influent	30,900	504	"	0.42	5.6	9
11,415	28,300	486	4.1	0.45	5.0	28
12,135	32,500	435	5.7	0.11	4.6	78
13,215	31,700	328	4.6	0.39	4.8	20
16,455	25,200	563	4.5	0.30	5.4	5
Influent	24,000	446	4.4	0.35	5.5	32
17,355	24,400	446	4.2	0.37	5.6	46
18,615	12,600	433	4.3	0.35	5.7	44
19,110	31,700	552	"	*	7.4	15

* Not recorded

Initial carbon charge: 1000 lb fresh.

The results obtained in the activated carbon treatment of olive brine used to store Spanish-style green olives are tabulated in Table VIII. The flow rate used was 2 gpm.

TABLE VIII

ACTIVATED CARBON TREATMENT OF BRINE USED TO STORE IMPORTED GREEN OLIVES

Effluent Volume, Gallons	C.O.D., mg/ liter	SS, mg/ liter	pH	Total Acidity, g Lactic Acid/100 g	NaCl Content, %	Light Transmittance, %
Influent	19,100	234	3.5	0.83	8.7	46**
90	2,000	22	9.1	<0.01	2.3	100
210	6,000	98	8.7	<0.01	8.3	70
330	7,800	63	8.4	<0.01	8.5	65
450	8,800	53	8.0	0.07	8.9	63
510	8,100	100	7.9	0.07	9.5	57
570	8,400	89	7.7	0.14	9.7	54

** Influent diluted with five parts of water.
Initial carbon charge: 1000 lb used (See Table VII)

Treatment of Processing Waters

A series of experiments on treatment of processing waters was conducted at Visalia after the storage brine reconditioning tabulated in Table III was completed. The treatment of strong lye rinse waters with activated carbon is summarized in Table IX. The flow rate was 2 gpm.

The carbon column reconditioning of Lindsay processing water was performed at Visalia and the reconditioned water was returned to Lindsay for evaluation. Four plastic lined bins, with covers, were filled with spent lye process water at Lindsay and delivered to Visalia. At the cannery, the liquid was siphoned into a 1000 gal. holding tank. One hundred lb of fresh carbon was placed at the top of the column before the pumping of the process water was started. The major part of the carbon within the tower was loaded with caustic and this was eluted as the solution passed through the carbon bed. The processing

TABLE IX

RECONDITIONING OF STRONG LYE RINSE WATER WITH ACTIVATED CARBON

Effluent Volume, Gallons	C.O.D., mg/ liter	SS, mg/ liter	pH	NaOH, g/ 100 g	NaCl Content, %	Light Transmittance, %
Influent	4,400	138	12.5	0.83	0.45	62**
75	500	< 1	9.5	0.03	0.01	96
150	1,400	< 1	11.1	0.04	0.01	82
225	1,400	1	12.0	0.19	0.10	62
300	1,400	7	12.4	0.69	0.23	63
375	1,700	3	12.4	0.70	0.21	49
450	2,000	12	12.4	0.71	0.13	52
525	1,500	18	12.4	0.80	0.24	67
600	2,200	15	12.4	0.80	0.32	57
675	1,800	12	12.5	0.80	0.17	48
750	1,900	22	12.5	0.80	0.22	41
825	2,200	26	12.5	0.80	0.20	19

** Influent diluted with five parts of water
Initial carbon charge: 180 lb fresh, 820 lb used (See Table III)

water was returned in clean bins for a reuse potential evaluation. A flow rate of 2 gpm was used. A summary of the analytical results are tabulated in Table X.

A fresh water backwash of approximately 720 gal. was used to reduce the lye concentration on the carbon before treatment was started on brine which had been used to transport olives from the final washing tanks to the can filling equipment. A charge of 120 lb of fresh carbon was loaded into the brine reconditioning unit. The transport brine was pumped through the carbon at a flow rate of 2 gpm. The flow rate and screen were checked at intervals; the rate needed adjustment periodically because of clogging of the wire cloth filter on the influent line by suspended solids in the transport brine. This was the only time this problem occurred during the project.

The results of this experiment are tabulated in Table XI.

TABLE X

TREATMENT OF PROCESSING WATER WITH ACTIVATED CARBON

Effluent Volume, Gallons	C.O.D., mg/ liter	pH	NaOH, g/per 100 g	NaCl Content, %	Light Transmittance, %
Influent	6,400	9.3	.022	0.11	55**
60	800	12.0	.334	0.05	100
180	2,000	11.8	.138	0.10	87
300	2,000	11.6	.087	0.12	93
420	2,300	11.3	.065	0.12	95
540	2,900	11.2	.058	0.11	94
640	2,800	11.1	.055	0.12	91

** Influent sample diluted with ten parts of water
Initial carbon charge: 100 lb fresh, 900 lb used (See Table IX)

TABLE XI

ACTIVATED CARBON TREATMENT OF TRANSPORT BRINE

Effluent Volume, Gallons	C.O.D., mg/ liter	SS, mg/ liter	pH	NaOH, g/ 100 g	NaCl Content, %	Light Transmittance, %
Influent	740	200	7.2	0	3.10	54
80	500	< 1	10.3	0.044	0.02	100
200	<20	"	10.0	0.007	2.20	"
320	<20	"	9.7	0.007	2.27	"
440	500	"	10.1	0.011	3.05	"

Carbon bed backwashed with 720 gals. of water before use.
Initial carbon charge: 100 lb fresh, 900 lb used (See Table X)

Iron Levels in Carbon Treated Brines

There was some concern about the level (8 to 16 ppm) of iron in reconditioned brine (caused by elution from the carbon) as a source of off-flavor in stored olives. Pairs of samples of influent and effluent from operation of the brine reconditioning unit at Oroville were collected and the iron level determined. The results are tabulated in the Appendix. The iron is present in the carbon due to the iron content of the coal from which the carbon was prepared; only part of the iron is removed by washing procedures used in the carbon manufacture.

Evaluation of Furnace Regenerated Carbon

Approximately 1000 lb of carbon (dry wt) in the form of a slurry in brine was removed from the brine reconditioning unit after treating 19,110 gal. of strong storage brine (See Table VII). The slurry was placed in 55 gal. metal drums and washed for 24 hr by placing fresh water hoses at the bottom of the drums and introducing water at the rate of 100 gph. The overflow spilled over the sides of the drum and was collected in the tank field gutter system. At the end of the washing period the carbon was placed on 40 mesh screening for dewatering. The moist carbon was transported to Brisbane, California for regeneration.

A second 1000 lb lot of spent carbon (dry wt) from the experiments at Madera (See Tables IV, V, and VI, stored for thirteen weeks) was regenerated at the same time as the washed carbon described above; this material was designated as unwashed.

The summary of the carbon regeneration as reported by the BSP Corporation is tabulated in Table XII (the discrepancies in values for dry wt of carbon found by NCA and BSP Corporation were not resolved due to loss of identity of tared containers) and the analytical results on the regenerated carbon in Table XIII.

The reactivated carbon was used to recharge the carbon bed section of the brine reconditioning unit in two separate operations. The first batch was the water washed, reactivated carbon which was used to recondition brine as summarized in Table XIV. The flow rate was 2 gpm for the first 480 gal. then 1 gpm for the remainder of the run. The unwashed, reactivated carbon was used to recondition

TABLE XII

OBSERVATIONS ON REGENERATION OF SPENT CARBON FROM THE BRINE RECONDITIONING UNIT

Operation	Washed	Unwashed
Analysis, as Received		
Percent Moisture	14.6	27.1
Apparent Density (A.D.), g/cc	.589	.544
Dry carbon, lb	638	974
Regenerated Product (A.D.)	.470	.457
Improvement (Change in A.D.), Percent	25	19
Furnace Temperature, °F		
Stage H - 1	200	200
2	800	1050
3	1000	1400
4	1650	1750
5	1700	1730
6	1750	1720
Scrubber Loss, lb/hr	.26	.63

Shaft speed 1.3 RPM, Zero draft, 30 hr operation time. Some smoking observed on unwashed material, afterburner not used.

TABLE XIII

ANALYTICAL RESULTS ON REGENERATED CARBON*

Sample Identity	Measurement			
	Molasses Number	Ash Content	Iodine Number	A.D. g/cc
Water-washed Before Regeneration	246	5.92	787	.510
Water-washed After Regeneration	232	6.47	845	.499
Salt-loaded Before Regeneration	208	7.30	455	.571
Salt-loaded After Regeneration	262	8.21	870	.490
Virgin	230	8.5	1000	.710

*Values reported by Calgon Center, Pittsburgh Activated Carbon Company, Pittsburgh, Pa. 15230.

brine as summarized in Table XV. The flow rate was 1.25 gpm. A comparison of the efficiencies of virgin; water-washed, reactived; and unwashed reactivated carbon is shown in Table XVI. The comparison was made on the basis of analysis of effluent brine for each carbon type after 5,000 gal. of brine of similar composition had been treated using approximately the same flow rate (See Tables VII, XIV and XV). It is recognized that this comparison of efficiencies is of doubtful utility due to single measurements of variables.

A number of small scale samples were regenerated and evaluated by the Pittsburgh Activated Carbon Company. Analysis of carbon put through a second furnace activation cycle on a small scale is tabulated in Table XVII.

TABLE XIV

ACTIVATED CARBON TREATMENT OF STORAGE BRINE USING CARBON WATER WASHED BEFORE FURNACE REACTIVATION

Effluent Volume, Gallons	C.O.D., mg/ liter	SS, mg/liter	pH	Total Acidity, g Lactic Acid/100 g	NaCl Content, %	Light Transmittance, %
Influent	32,900	496	4.2	.547	5.7	22
240	S.D.*	S.D.	8.7	S.D.	6.1	71
480	S.D.	S.D.	5.1	.253	6.1	45
600	5,000	S.D.	4.8	.309	6.1	40
840	19,000	489	5.2	.211	5.9	22
Influent	33,300	466	4.2	.464	7.5	20
1,920	25,300	477	4.1	.492	7.1	74
3,200	32,900	452	4.3	.422	7.5	64
5,073	32,500	507	4.1	.436	7.5	66

* S.D. - Sample delayed in delivery to Berkeley Laboratory; accuracy of results were uncertain.

Initial carbon charge: 1000 lb reactivated.

TABLE XV

ACTIVATED CARBON TREATMENT OF STORAGE BRINE USING CARBON UNWASHED BEFORE FURNACE REACTIVATION

Effluent Volume, Gallons	C.O.D., mg/ liter	SS, mg/liter	pH	Total Acidity, g Lactic Acid/100 g	NaCl Content, %	Light Transmittance, %
Influent	28,600	440	4.5	.337	6.0	25
1,870	16,500	457	6.1	.03	6.0	87
3,670	21,500	406	4.8	.211	6.0	93
5,496	26,700	457	4.3	.351	6.0	97

Initial carbon charge: 1000 lb reactivated.

TABLE XVI

COMPARISON OF EFFICIENCIES OF VARIOUS TYPES OF CARBON IN RECONDITIONING STORAGE BRINE

Carbon Type	C.O.D. reduction, %	SS reduction, %	Light Transmittance, %
Virgin	12.6	13.7	50
Water Washed Reactivated	2.4	(2.2)*	66
Unwashed, Reactivated	17.8	2.3	95

*Value increased as did others at 5190 and 5496 gal., resp.

TABLE XVII

ANALYSIS OF ACTIVATED CARBON AFTER SECOND FURNACE REACTIVATION CYCLE

Carbon Sample	Analysis			
	Molasses Number	Ash	Iodine Number	A.D., g/cc
Spent	210	4.51	413	.640
Laboratory Regeneration*	272	6.12	930	.460
Laboratory Regeneration after washing**	345	6.42	789	.452

*Steam/Air at 1750 CF for 42 min; the volume yield was 94.5%.

**Washed with tap water for 16 hr, rinsed with de-ionized water, regenerated as stated above; the volume yield was 95.5%.

Storage of Reconditioned Brine Without Olives

To get the most efficient use of a commercial scale carbon column unit it would be desirable to operate it several months before freshly harvested olives are received for storage. For this type of operation, it would be necessary to store reconditioned brine in the absence of olives for periods of three to six months. It has been demonstrated on many occasions that used olive storage brines develop yeast, mold and bacterial growth in the absence of green olives. These changes in the

storage brine make it unsuitable for reuse because olives stored in such brines produce a final product of inferior flavor and texture.

There was considerable question about the storage performance of carbon-treated brine in the absence of green olives.

The first 5450 gal. of reconditioned brine described in Table II were stored in a redwood tank starting on October 24, 1968. The pH of the brine was adjusted from 4.1 to 3.7 by the addition of 20 gal. of 37 percent (food grade) hydrochloric acid. The brine in this storage tank developed a yeast or mold pellicle after 3 to 4 weeks of storage. The brine in the tank was reported by plant personnel to have an undesirable odor after three months of storage; however, project personnel could detect no significant undesirable odor on smelling the brine after three and four months of storage.

The 10,000 gal. of storage brines treated by the carbon column at Visalia as described in Table III were stored in two 5,000 gal. tanks. The reconditioned brine had an average salt content of 1.8 percent, a pH of 4.0 and a total acidity of 0.29 percent. These storage brines were adjusted to lower pH's by the addition of a mixture of lactic and acetic acids. The brine in the two tanks was circulated by pumping to break up surface growth of yeasts and molds. The brine had a good odor and appearance to project personnel after six weeks of storage in the absence of green olives.

No systemic observations were made on reconditioned storage brines stored in the absence of olives at Madera. It was reported that one of the tanks of reconditioned brine (See Table IV) developed an objectionable odor after approximately two months of storage and the brine was pumped to an evaporation pond.

The most detailed observation on storage of reconditioned storage brines was made in Oroville. Brines having storage periods of 4, 36 and 64 days were used in olive storage experiments. The brine with the longest storage period developed an odor described as "brassy" by the plant personnel. Due to this odor, the plant management was reluctant to run full scale storage experiments in this reconditioned brine and only small scale (100 lb lots) storage was investigated.

Storage of Olives in Reconditioned Brine

The experimental storage of [illegible]ns of olives in 1,530 gal. of

reconditioned brine (See Table II; effluent from the last 1500 gal. treated was used) was followed with intense interest. The olives used were medium Manzanillos and the brine had a starting salometer reading of 24° at the time storage started on October 23, 1968; the salt content of the brine was increased to 30° during the first two weeks of storage by the addition of sodium chloride. After three months of storage, the salt concentration was raised to 10 percent (40° salometry). A sample of olives was taken from the storage tank each week and examined for signs of spoilage or shrivel. The olives appeared to be undergoing a normal fermentation and storage behavior. Small portions of the stored olives were processed and canned on December 23, 1968; February 24, 1969; and on April 24, 1969. A control sample of olives from normal storage tanks was obtained for each of the canning periods of the experimental olives.

At the end of the storage experiment, the olives were used in commercial production. There was no report of any quality defect in these olives as they were marketed in routine fashion.

Due to the fact that the olives prepared from those stored in reconditioned brine might have an unusual content of potential spoilage microorganisms, a sterility test was run on canned olives. Cultures were prepared from the experimental sample and a commercial sample which served as a control (pH 6.45 and 6.55, respectively) in three types of media with incubation at 30 and 50°C. No growth was observed in any cultured sample from the olives. Microscopic examination of the contents of cans after 6 days of incubation at 30°C (all cans remained flat) detected a few bacterial cells. The canned olives were judged to be commercially sterile.

A series of ten 100 lb samples of freshly harvested Giant Sevillano olives were stored in three types of reconditioned storage brines. Some characteristics of these storage brines are tabulated in Table XVIII. Samples of reconditioned storage brine from three tanks [representing the last 5000 gal. of effluent described in Table VII (69-1); the first 2000 gal. of effluent described in Table XIV (69-3); and the last 1000 gal. of effluent described in Table XV (69-2)] was diluted with fresh water to a salometer reading of 12°; 10 gal. of this brine was used for each of the ten 100 lb lots of olives. The ratio of brine volume : olive weight was twice that of normal commercial practice but was necessary for the configurations of the 32 gal. pails used and the companion redwood floats which keep the olives submerged.

The sodium chloride content of the brine was increased by the addition of salt by the schedule shown in the Appendix. The olives

TABLE XVIII

SMALL SCALE OLIVE STORAGE EXPERIMENTS

Storage Pail Code Number	Type Carbon Used in Reconditioning	Brine to Carbon Ratio; Gallons : Pounds	Post-Reconditioning Storage Time, Days
69 - 1 A	Fresh	14 : 1	64
B			
C			
D			
69 - 2 A	Salt-Loaded	2 : 1	36
B	Reactivated		
C			
69 - 3 A	Water - Washed	5 : 1	4
B	Reactivated		
C			

were judged to be undergoing a normal storage in all three types of brines. Approximately 30 lb of olives were removed from each storage pail, put in plastic screen bags and carried through a commercial lye cure, oxidation, rinsing, and canning. The total storage period for olives in these samples of reconditioned brine was 4.5 months.

Quality of Canned Olives From Storage in Reconditioned Brines

Samples of olives taken from the storage tank in Lindsay on April 24, 1969, were prepared and canned by Consolidated Olive Growers personnel; these samples had die code 3 D 685/BD 61 and were marked Tank 419 with paint on the sides of the cans. A commercial sample of medium Manzanillo olives of the same storage period was used as a comparison sample.

The canned olives were presented to a taste panel of 16 people for difference testing (triangle presentation). Three samples (two identical and one different) were presented on four consecutive days. Of the total of 64 judgments, 24 correct matchings of the identical samples were obtained. Since a purely random result would yield 21.33/64 correct judgments, it can be concluded that the samples from olives stored for six months in reconditioned brine were not significantly different in flavor from the samples from olives stored in virgin brine.

A more extensive test of the storage of freshly harvested olives in reconditioned brines of various extent of treatment and storage period after reconditioning was conducted at Oroville.

The samples from the three different reconditioned brines and a control sample from commercial production (all Giant Sevillano olives) were presented to a panel for flavor preference ranking in eight daily sessions with random order of presentation (1 = best, 4 = worst flavor). Two series of tests were made, one having replicates of the 69-1 series which represented the potentially poorest quality storage brine. The results of these quality ranking tests are tabulated in Table XIX. A flavor ranking of 2.50 would be expected if the samples presented were judged to be identical in flavor.

TABLE XIX

FLAVOR RANKING OF CANNED RIPE OLIVES

Storage Code No.	Brine : Carbon Ratio, Gallons : Pounds	Post Reconditioning Storage Time, Days	Flavor Ranking
69-1 A	14 : 1	64	2.57
B			2.13
D			2.14
69-2 B	2 : 1	36	2.81
C			2.85
69-3 B	5 : 1	4	2.62
CONTROL	1st Test		2.39
	2nd Test		2.45

SECTION VII

DISCUSSION

Treatment of High Salt Content Storage Brines

Substantial changes in the values for pH, total acidity, C.O.D. and color were observed when fresh carbon contacted the brine; the level of suspended solids followed a random pattern. Increases in the pH of effluent samples and decreases in total acidity were found as the brine contacted fresh carbon at low influent volumes. However, the pH and total acidity were similar in both the influent and effluent brines as the effluent volume increased (See Tables II, IV, VII). The retention of the total acidity in the effluent from carbon treatment is desirable since the lactic acid (which is the major contributor to acidity) is a preservative in the brine storage of olives. The C.O.D. of the effluent brine dropped sharply after each addition of fresh carbon to the reconditioning unit. The general trend of the C.O.D. values was to increase up to the influent level as the volume put through the carbon bed increased (See Tables II and VII). The influent storage brine was usually dark yellow-green or light reddish-orange. The effluent brine ranged in color from colorless to light greenish-yellow. The values for light transmittance, which provided a more objective measure of color than the visual estimation, correlated well with the extent of treatment. The values for light transmittance were high for low effluent volume : carbon ratios and low for high effluent : carbon ratios (See Table VII).

The salt content of storage brines showed little change due to passage through the carbon bed; the only change was a transitory one as low volumes of brine contacted freshly exposed carbon (See Tables II, IV, VII).

Treatment of Low Salt Content Storage Brine

A single experiment on the treatment of low salt, high lactic acid, storage brine was conducted (See Table III). The carbon treatment of low salt content brine was effective in removing color and retaining lactic acid. The carbon treatment had little effect on C.O.D.

The reconditioned brine was stored and observed for a period of six weeks. The brine did not develop undesirable odors or change significantly in color. The reconditioned brine was reused for the storage of olives with no untoward effect on the quality of the final product.

Treatment of Salt Free Storage Brine

While not a part of the original project plan, the prospect that a considerable portion of commercial olive production would use the salt-free storage system made it of interest to determine the result of treatment of liquid waste from this type of storage practice. It was also felt that the used salt-free solution might condition spent carbon and cause it to perform for longer periods in the treatment of conventional storage brines. The conditioning of spent carbon might take place due to displacement of adsorbed organic material from the carbon by the lactic and acetic acids in the salt-free storage solution. It was also of interest to determine the fate of the benzoic acid in the salt-free storage solution during activated carbon treatment. Removal of the benzoic acid would probably improve the biological degradation of the high B.O.D. material represented by the liquid waste discharged after use of salt-free storage solutions. On the other hand, the removal of benzoic acid by the carbon treatment would detract from the reuse potential of reconditioned solutions since this acid is one of the most costly components.

The results of treatment of a salt-free storage solution are summarized in Table V. The activated carbon treatment of a salt-free storage solution reduces the C.O.D. value markedly at low effluent volumes (i.e. from 45,000 to 21,000 mg/l at 400 gal. of effluent). The total acidity is also substantially reduced in the initial effluent volumes. The C.O.D. increases to about 75 percent of the influent level at the point where total acidity values return to the influent level. The effluent was colorless at all volumes studied. Ninety percent of the benzoic acid present in the influent was removed by the carbon treatment.

The passage of the salt-free storage solution through the carbon bed appeared to have a beneficial effect on carbon efficiency.

An additional 4800 gal. of high salt content storage brine was passed through the carbon and resulted in an effluent with high light-transmittance readings (See Table VI).

Treatment of Processing Waters

The carbon treatment of olive brine was originally designed for high salt content storage brines; it is this application which would remove most of the sodium chloride from olive cannery liquid waste discharges. However, if the activated carbon treatment technology were adopted for the reconditioning of high salt content storage brines, the availability of the equipment in the cannery may make the treatment of processing waters economically attractive.

The processing waters are those solutions used for soaking and washing olives as they are prepared for canning. For the reasons stated above and in the Introduction, three types of processing waters were used in brief, exploratory studies of the effect of activated carbon treatment on the reuse potential.

A lye rinse water of 825 gal. volume was passed through the carbon bed to explore the potential of reconditioning such processing water. The analytical results from this experiment are tabulated in Table IX. The SS and C.O.D. content of the influent were reduced by the carbon treatment; a reduction of 91 percent for the SS content and 62 percent for the C.O.D. level (on the average) was observed. The concentration of sodium hydroxide in the effluent returned to nearly the influent level after one-half of the liquid had passed through the carbon bed. The reconditioned strong lye rinse water was used as make-up water in lye curing tanks. The cannery personnel who evaluated this reuse found the practice to be satisfactory.

Results of the treatment of processing water with activated carbon are summarized in Table X. The major portion of the carbon within the unit was saturated with sodium hydroxide from a previous use (See Table IX) and this was partially eluted as the processing water passed through the carbon bed. The colored components in the influent were almost completely adsorbed by the carbon. The high pH of the effluent was due to the previous use of

the carbon; the effluent had a low salt content. After 640 gal., the C.O.D. value for the effluent was 44 percent of the influent value. The reconditioned processing water was reused in commercial production as a soaking solution after a second lye curing of olives. The cannery personnel evaluating the reuse reported that the flavor of the olives after the process seemed to be the same as olives having normal fresh water soaking.

Analytical results of a transport brine reconditioning experiment are tabulated in Table XI. The salt content of the effluent reached the influent level after approximately 440 gal. of brine had passed through the carbon bed. Colored components and SS were almost completely removed. The reconditioned transport brine was reused successfully in the commercial operation.

Analytical Indicators of Reconditioned Brine Quality

Five analytical measurements were used to evaluate the quality of activated carbon treated brines: C.O.D., pH, total acidity, SS, and light transmittance. It was found that for the major part of the treated brine, the values of pH and total acidity (as well as salt content) were relatively constant (See Tables II and VII). The SS content was variable in a random fashion due to the sporadic discharge of carbon fines and retained SS (see Tables III and VII).

The only indicators which showed a systematic variation related to the extent of treatment which the brines received were C.O.D. and light transmittance. In a majority of the storage brine treatment experiments, considerable color was removed without corresponding substantial changes in the C.O.D. values (See Tables II, III, IV, XIV, and XV). For this reason it was concluded that brine color was the most sensitive index of reconditioned brine quality. This conclusion appeared to be substantiated by the fact that reconditioned brines of high C.O.D. content and medium light transmittance values were used successfully in the storage of freshly harvested olives (See Tables II, VII, XIV, XV, and XVII).

Flavor of Olives Stored in Reconditioned Brines

The flavor panel testing of canned black ripe olives comparing samples from storage in activated carbon reconditioned brines and in freshly prepared brines did not establish any difference in quality. The samples from the 15 ton scale storage experiment were not significantly different from olives of the same size and variety stored for the same period in freshly prepared brine. A confirmation of this result was obtained indirectly by the fact that the olives stored in reconditioned brine were sold with no adverse comments received on the quality of the canned product.

The storage experiments on small lots of olives in three different types of reconditioned brines were evaluated by a laboratory taste panel. The samples prepared from olives stored in brine having the lowest extent of treatment and longest storage period before use were ranked as the best of the four samples presented. The three samples from the 69-1 storage conditions (See Table XVIII) showed values of 2.13, 2.14 and 2.57. This result suggests that the quality of the olives from individual storage pails was different. The two values obtained for the ranking of the commercial control sample were 2.39 and 2.45. This result indicates the precision in ranking to be ± 0.06. The overall conclusion from the taste panel results on all the samples from olives stored in reconditioned brine was that their quality was similar to that of olives stored in virgin brine.

Use of Regenerated Carbon

All of the results obtained in the evaluation of the performance of carbon reactivated for reuse indicate that the reactivated carbon is as efficient as virgin carbon (See Table XVI). A particularly significant fact is the lack of a requirement for water washing before activation.

Cost Estimates for Brine Reconditioning

The basis for any decision to use the brine reconditioning technology is its contribution to the wholesale cost of the final product produced for sale compared to the costs generated by alternative methods of operation. The alternatives which are available to the industry which will keep their salt discharges at or within levels which meet the water quality standards are:

1. Conventional operation with dilution of saline wastes with fresh water to permissable salt level for discharge.

2. Conversion of operation to complete fresh curing of olives as harvested.

3. Conventional operation with ponding of saline wastes.

4. Use of salt-free storage systems.

5. Conventional operation with activated carbon reconditioning and reuse of storage brines and saline processing waters.

6. Combinations of the above methods of operation.

It is beyond the scope of this report to give a detailed cost analysis of the various alternative methods of operation outlined above. A detailed cost estimate will be presented on the brine reconditioning approach based on two options: 1. brine reconditioning at a single site on a 5,000 tons of olives per year basis with a single use of activated carbon and, 2. brine reconditioning at ten individual plants with a central carbon reactivation site for a total of 50,000 tons of olives per year.

The basis for the cost estimate is listed in Table XX. The figures are derived from the results obtained in this study and are considered conservative estimates which allow a safety factor for raw olive variation and environmental conditions other than those observed during the experimental period of this project. The critical value of 10 gal.of reconditioned brine for each lb of carbon is based on the single large scale storage experiment and alternate cost estimates based on ratios of 15 gal. and 20 gal. of brine for each lb of carbon are included for comparison.

TABLE XX

BASIS OF CALCULATION OF CARBON COLUMN SIZE, CARBON INVENTORY AND CARBON REGENERATION REQUIREMENTS

Subject	Value
Annual Weight of Olives Stored in Brine at A Single Location	5000 tons
Volume of Stored Brine Required Per Ton of Fresh Olives	100 gal.
Period of Receiving Freshly Harvested Olives	6 weeks
Storage Period for Reconditioned Brine Before Use	6 weeks
Volume of Brine/Weight of Carbon (See Tables II, VII, XIV, XV)	10-20 gal./lb
Volume of Brine Required Per Week for 12 Weeks	41,667 gal.
Annual Carbon Requirement (Single Use) at 10 gal./lb	50,000 lb
Carbon Inventory for Central Regeneration Facility Receiving Spent Carbon from Ten Brine Reconditioning Plants	405,000 lb
Olives Harvested for Processing; Average per year for Period 1961 Through 1968	37,370 tons

Assumptions:

Operating Period: 12 weeks; 7 days/week; one 8-hr shift/day, as is standard practice in the olive processing industry.

Average Flow Through Adsorption System

$$\frac{500,000}{12\ (7)} = 5,950 \text{ gpd or } 12.5 \text{ gpm}$$

Designed Flow 0.5 gpm/ft^2 or 0.025 gpm/ft^3

(In pilot unit, best color removal per unit wt of carbon was at 0.027 gpm/ft^3 or 0.75 gpm/1.4 ft^2; See Table VII)

Diameter of Carbon Bed: 5.6 ft

Height of Carbon bed for adequate contact time: 20 ft

Carbon volume: 500 ft^3/ column

Carbon weight: 13,500 lbs

Carbon exhausted per day: 595 lbs

Time to exhaust column: 22.7 days

Design: Two fixed bed columns in series

OPTION 1

Capital Cost	Reconditioned Brine to Act. Carbon Ratio		
	10 gal./lb	15 gal./lb	20 gal./lb
2 - 5.6 x 20 ft redwood tanks at $1000	$ 2,000	2,000	2,000
Screens, distributor plants, etc.	1,000	1,000	1,000
Installation cost	9,180	9,180	9,180
Total capital cost	12,180	12,180	12,180
Amortization, Annual Cost	1,820	1,820	1,820

OPTION 1 (Cont'd.)

	Reconditioned Brine to Act. Carbon Ratio		
	10 gal./lb	15 gal./lb	20 gal./lb
Operating Costs			
Labor (1.6 hrs/day/7 days/week, 12 weeks at 5.00/hr including fringe benefits)	$ 672	672	672
Power	60	60	60
Carbon (at $ .31/lb)	15,500	10,333	7,750
Carbon disposal (sanitary land fills at $ 8.00/ton)	1,200	800	600
Maintenance	348	348	348
Total Annual Cost	$ 19,600	14,033	11,250
Recovery value of brine components			
Water, 500,000 gal. at $ .20/1000 gal.	$ 100	100	100
Sewer tax (same basis)	100	100	100
Salt at $ 15/ton	1,200	1,200	1,200
Sub-total	$ 1,400	1,400	1,400
Net annual cost -	18,200	12,633	9,850
Cost per ton of olives -	3.64	2.53	1.97
Cost per 1000 gal. of storage brine -	36.40	25.30	19.70

OPTION 2

	Reconditioned Brine to Act. Carbon Ratio		
	10 gal./lb	15 gal./lb	20 gal./lb
Capital cost			
Installed brine reconditioning units (12,180 x 10)	$ 121,800	121,800	121,800
1 - 7 ft I.D. x 6 ft hearth furnace	50,000	50,000	50,000

OPTION 2 (Cont'd.)

	Reconditioned Brine to Act. Carbon Ratio		
	10 gal./lb	15 gal./lb	20 gal./lb
Furnace feed tank	2,000	2,000	2,000
Dewatering screws	7,000	7,000	7,000
Quench tank	1,600	1,600	1,600
Carbon collection tank	2,000	2,000	2,000
Installation of carbon regeneration plant	37,800	37,800	37,800
Total capital cost	222,200	222,200	222,200
Amortization,*Annual Cost	33,180	33,180	33,180
Carbon inventory	125,600	83,600	62,800
Interest loss on carbon inventory, Annual	9,300	6,200	4,650
Operating Costs			
Carbon make up			
10 plants x 50,000 lb/plant 10 percent loss x $0.31/lb	15,500	10,333	7,750
Labor	3,360	2,240	1,680
Power (0.05 kw/lb at $0.01/kwh)	250	188	125
Fuel (3200 BTU/lb carbon)	400	300	200
Carbon hauling ($0.10 per ton-mile, 200 mile round trip distance)	5,000	3,750	2,500

*8 percent interest compounded annually for a replacement period of 10 years.

OPTION 2 (Cont'd.)

	Reconditioned Brine to Act. Carbon Ratio		
	10 gal./lb	15 gal./lb	20 gal./lb
Maintenance	250	250	250
Operation of brine reconditioning units (No carbon costs or disposal costs) 10 plants x $1080 per plant - 10(672 + 60 + 348)	10,800	10,800	10,800
Total Annual Cost	$ 78,040	67,241	61,135
Recovery Value of Brine; water, salt and sewer tax savings	14,000	14,000	14,000
Net Annual Cost	64,040	53,241	47,135
Net Annual Cost per Cannery	6,404	5,324	4,714
Cost Per Ton of Olives	1.28	1.06	0.94
Cost per 1000 gal. of storage brine	12.81	10.64	9.42

SECTION VIII

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The following project team was responsible for the operation of the brine reconditioning unit, the sample collection, and sample analysis:

Walter W. Rose	Harry J. Maagdenberg
Jennie Marano	Michael Iverson

Valuable contributions to the reporting of the results of the project were made by:

Edwin S. Doyle	Stuart Judd

Walter A. Mercer
Project Director

Jack W. Ralls
Project Coordinator

SECTION IX

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SECTION X

PATENTS AND PUBLICATIONS

No patents have issued as a result of inventions made during the course of this project. No patent applications have been made, or are planned to be made, by the National Canners Association as a result of work done in this project.

Several presentations of work done in the project have been made orally during 1968, 1969 and 1970. The first printed account of results from the project will appear in the proceedings of the National Food Processing Waste Symposium, Portland, Oregon, April 6 - 8, 1970.

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SECTION XI

APPENDICES

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Volume Measurements

A simple measurement, to obtain the flow rate volume from the carbon tower, was employed using a stop watch and pre-calibrated plastic container. Tank volumes were either calculated from dimensions or from flow rate data.

Sampling

Grab samples from the influent, effluent and tower port spigots were obtained at specified intervals of time. Quart glass containers were used whenever possible to eliminate contamination of the sample. Each container was clearly labeled by sampling point, pump rate, date, and time of sampling.

Sample Storage

Samples from the carbon tower were immediately taken to the plant laboratory refrigerator for temporary storage. After completion of a regular experiment the samples were gathered and transported in polystyrene ice chests for the return trip to the Berkeley laboratory. At the destination the samples were refrigerated for subsequent analysis.

Chemical Oxygen Demand

The Jeris Modified, C.O.D. tests (5) were employed for all analytical data presented in this report. This "rapid" C.O.D. procedure involves the addition of waste sample to a flask containing mercuric sulfate. After mixing, 25 ml of dichromate-acid-silver sulfate misture is added, mixed and placed on a pre-heated hot plate. A thermometer is inserted in the flask, and the temperature is checked as the mixture is heated. When 165°C is reached, the sample is withdrawn and cooled. (Care must be employed in heating the sample because of the rapid rise in temperature.) Water is added cautiously, and after further cooling, the solution is titrated with ferrous ammonium sulfate in the presence of ferroin indicator.

Suspended Solids

A millipore filter apparatus with a 47 mm Type E glass fiber filter disc is employed in this procedure. The filter disc is dried in an oven at 103°C for 1 hr, (30 min in a mechanical convection oven) cooled to room temperature in a desiccator and weighed. The filter disc is placed in the suction apparatus with tweezers. A volume of sample to be taken for filtration will depend on the concentration of the suspended matter in the sample and should be as large as practical. 100 ml portions are used throughout the report unless otherwise noted. A well-mixed sample is measured out with a graduated cylinder and filtered slowly by suction.

Leaving the suction on, with 10 ml distilled water to remove soluble salts. Dry the filter disc and solids at 103°C for 1 hr as previously and allow the disc to cool to room temperature in a desiccator before weighing.

The suspended solids are calculated in ppm

$$\text{mg/liter S.S.} = \frac{R \times 10^6}{\text{Sample volume}}$$

where R = weight of dried residue.

Color

The color of the waste samples was measured in a Bausch & Lomb Model 20 Spectrophotometer. The instrument was standardized at 100% transmittance with distilled water at the desired wave lengths of 425 and 450 mμ. These wave lengths were selected as those at which the olive brines showed maximum light absorption. Samples are read directly in percent transmittance. Aliquots of diluted samples are necessary if readings fall below 10 percent transmittance.

pH

The measurement of pH of a solution is obtained by the use of a commercial electrometric portable pH meter. The meter is first standardized with a buffered pH solution. The appropriate probes are immersed into the solution under test and the pH determined by reading the value directly from the meter.

Total Acidity

In a food plant material, total acidity is a measure of the amount of acidic substances principally present as organic acids and carbon dioxide. A 10 ml sample is placed in a 150 ml beaker. Add approximately 40 ml of distilled water. Using a glass electrode pH meter, titrate with 0.1560 N sodium hydroxide with constant stirring to an end point of pH 8.3. Make sure the tip of the buret is clean and free from solid alkali. Read the number of ml of sodium hydroxide used to one-tenth of a ml, and divide by ten. A correction factor of 1.405 is used to convert the results into percent of acid in terms of lactic acid.

Salt Content

Pipet 5 mls of an aliquot (5/100 for brine) into a 100 ml beaker. Add approximately 25 ml of water. Use a PHOTOVOLT Model 115 Electronic pH meter with the silver and calomel electrodes. Immerse the electrodes in the solution and set the main switch to reference. Adjust the pH scale at 7.0 with the standardizing control knob. Titrate with .0855 N silver nitrate (do not titrate with silver nitrate solution that has been exposed to light in the buret for more than a few hours), with constant stirring until the needle rests at 11.5. Read the number of ml of silver nitrate used to one-tenth of a ml and divide by ten. The result is the percent salt.

Percent Sodium Hydroxide

A suitable sample of lye water (less than 25 ml) is titrated with 0.0908 N H_2SO_4 with stirring to an end point of pH 7.0. The percentage of NaOH in the lye water is given by:

$$\% \text{ NaOH} = \frac{4 (A \times B)}{C}$$

Where: A = volume of acid used
B = normality of the acid
C = size of sample to be titrated, in ml

Iron Determinations

10 ml samples of brine were placed in evaporating dishes and heated under infrared lamps until the water was removed. The dishes were

placed in a muffle at 325°C until smoking ceased. The muffle furnace door was closed and the temperature was increased to 550°C. The dishes were removed after 1 - 2 hours and the ash broken up, wet with water, dried and re-ashed for 1 hour. The residue from the ashing was dissolved in 2 ml of 1 : 1 hydrochloric acid : water. The solution was heated for approximately 2 minutes under heat lamps and then transferred to 25 ml volumetric flasks and diluted to the mark with distilled water used to rinse the ashed sample dish.

The analytical method was adapted from that of Diehl and Smith (6). Reagents Bathophenanthroline, 0.001 M Solution. Prepare a 50 percent ethyl alcohol solution of bathophenanthroline by dissolving 0.0332 g of 4, 7-diphenyl-1, 10-phenanthroline ($C_{24}H_{16}N_2$, Mol. wt 332; G. Frederick Smith Chemical Company, Item No. 108) in 50 ml of ethyl alcohol and diluting with 50 ml of iron-free water. Store this solution in a glass stoppered, reagent bottle.

Hydroxylamine hydrochloride, 10 percent iron-free solution. Reagent grade hydroxylamine chloride contains appreciable amounts of iron. Dissolve 10 g of hydroxylamine chloride in 100 ml of water in a 125 ml separatory funnel. Add 2 ml M bathophenanthroline and mix well. Add 10 ml of isoamyl alcohol and shake vigorously. Allow the liquids to separate and draw off the lower, aqueous layer into a second separatory funnel. Add 2 ml of 0.001 M bathophenanthroline and repeat the extraction to insure complete removal of iron. Store iron-free hydroxylamine chloride solution in a glass-stoppered, reagent bottle. This solution has a pH of 1.5 to 1.75. It has been shown that all excess bathophenanthroline is extracted from solutions purified in this manner. The small amount of iso-amyl alcohol left in the solution is not detrimental.

Sodium Acetate, 20 percent iron-free buffer solution. Dissolve 20 g of sodium acetate in 100 ml of water in a 125 ml separatory funnel. Add 2 ml of 10 percent hydroxylamine hydrochloride solution to reduce the iron present. Add 2 ml of 0.001 M bathophenanthroline and mix well. Add 10 ml of iso-amyl alcohol and shake vigorously. Allow the liquids to separate and draw off the lower, aqueous layer into a second separatory funnel. Repeat the separation to insure complete removal of iron. Store the solution in a glass-stoppered reagent bottle.

Iso-amyl alcohol. Reagent grade iso-amyl alcohol may be used without further purification. Technical grade material must be distilled before use. N-amyl or n-hexyl alcohol also can be used.

Standard Iron Solution. 10 and 1.0 ppm Fe. A standard iron solution may be prepared from primary standard electrolytic iron (G. Frederick Smith Catalog, Item No. 226, p. 45) by dissolving a suitable weighed quantity in HCl and diluting to a known volume.

Five (5) ml of dissolved ash solution (equivalent to 2 ml of olive brine) was pipetted into a 125 ml separatory funnel containing 10 ml water and 2 ml hydroxylamine solution. The solution was mixed and allowed to stand for 5 min for all the iron to be reduced to the ferrous form. After 5 min 2 ml of sodium acetate buffer solution and 4 ml bathophenanthroline were added and mixed. To this solution 6 ml of iso-amyl alcohol was added and extracted by shaking vigorously. The layers were allowed to separate and the lower, aqueous, layer was discarded. The alcohol layer was run into one of a matched set of Evelyn colorimeter tubes. The separatory funnel was rinsed twice with 5 ml portions of 80 percent ethanol. The rinsings were added to the Evelyn tube and the solution diluted with alcohol to 25 ml. A reagent blank was also prepared in the same manner. The transmission was read with a 515 mμ filter on an Evelyn Photoelectric Colorimeter (Rubicon Co., Philadelphia, Pa.). A calibration curve can be made with standard iron solutions extracted as above. The experimental values can be read from the curve. The ppm Fe in the olive brine was calculated by applying the appropriate dilution factor.

Olive Taste Panel

A laboratory taste panel room was used for all laboratory taste tests. The room was furnished with a table, partitioned into eight booths, and eight folding chairs. The tests were carried out under conditions of low illumination so that the olives were not judged by appearance. A triangle presentation of three samples or a series of four samples were presented for preference ranking. For the triangle test 3 olives from one can were placed in each of two paper cubs. The third paper cup held 3 olives of the designated odd sample. The order of presentation (odd sample in cups marked L, M, or N) was randomized. The samples were presented in an aluminum cupcake tray along with a cup of cold water.

For the preference ranking test, 2 olives from each of 4 cans of samples were placed in four different cups coded L, M, N, and O.

The panelist was asked to complete the scoring sheets shown on the next two pages.

CANNED OLIVE FLAVOR

Instructions: Go to a lighted booth. Sit down and taste samples. Mark results and write initials on scoring sheet. Turn off light. Take tray of samples and scoring sheet to cutting room.

You are asked to taste three olive samples. Two of the samples are identical and one is different. Put a check mark (✓) after the two identical samples.

Code	Duplicate Samples
L	
M	
N	

Taster's initials _____ Date _____

OLIVE TASTE PANEL

Please taste and rank samples in order of flavor preference. Take completed scoring sheets and used sample tray to cutting room.

Code	Flavor Ranking 1 = Best; 4 = Worst
L	
M	
N	
O	

Date _____ Taster's initials _____

Work at Lindsay

TABLE XXI

ANALYSIS OF SAMPLES COLLECTED AT SAMPLING PORTS- (Lindsay)

(See Table II)

Date	Gallons of Effluent	Port Number	Flow Rate, gpm	pH	Percent NaCl	C.O.D., mg/liter
10-16-68	270	1	3	4.6	5.2	800
"	450	1	3	4.5	5.1	N.M.
"	450	2	3	4.7	5.3	N.M.
"	630	1	3	4.5	5.4	N.M.
"	630	2	3	4.4	5.4	N.M.
"	630	3	3	4.5	5.4	N.M.
"	900	1	3	4.4	5.5	N.M.
"	990	2	3	4.6	5.5	N.M.
"	990	3	3	4.4	5.4	N.M.
"	990	5	3	5.5	5.5	N.M.
"	1350	1	2	4.4	5.4	N.M.
"	"	2	2	4.4	5.4	N.M.
"	"	3	2	4.4	5.5	N.M.
"	"	5	2	4.9	5.5	N.M.
10-17	2010	1	2	4.4	5.3	N.M.
"	"	2	2	4.4	5.4	N.M.
"	"	3	2	4.6	5.4	N.M.
"	"	5	2	5.1	5.4	9000
"	2910	1	2	4.3	5.5	N.M.
"	"	2	2	4.4	5.5	N.M.
"	"	3	2	4.4	5.4	N.M.
"	"	5	2	4.3	5.5	N.M.
" *	3150	5	2	4.3	5.5	N.M.
"	3510	3	2	4.2	5.3	N.M.
		5	2	4.3	5.5	N.M.
"	3750	3	2	4.3	5.5	16,500
"	"	5	2	4.2	5.5	12,800
"	3990	3	2	4.3	5.5	16,400
"	"	5	2	4.2	5.5	13,600
10-18	4660	3	2	4.2	5.5	15,900
"	"	5	2	4.2	5.5	15,000
" *	5300	2	2.5	4.1	5.8	16,700
"	"	3	2.5	4.4	5.8	15,800
"	"	5	2.5	4.2	5.8	15,300
"**	5625	3	2.5	4.2	5.8	15,100

Work at Lindsay (Cont'd.)

ANALYSIS OF SAMPLES COLLECTED AT SAMPLING PORTS (Cont'd)

Date	Gallons of Effluent	Port Number	Flow Rate, gpm	pH	Percent NaCl	C.O.D., mg/liter
10-18		5	2.5	4.2	5.8	15,300
"	6470	3	2.5	4.0	6.0	11,400
"	6470	5	2.5	4.3	6.0	10,700
10-19 *	7355	3	2.5	4.2	6.0	15,500
"	7355	5	2.5	4.2	6.2	14,800
"	7680	5	2.5	4.2	6.2	16,800
" *	7905	5	2.5	4.5	6.2	14,800
"	8375	5	2.5	4.0	6.2	15,400
"	8400	5	2.5	4.0	6.2	14,600
"	8700	5	2.5	4.0	6.0	17,700
10-20	9150	5	2.5	4.0	N.M.	N.M.
"	9650	5	2.5	4.0	N.M.	N.M.
" *	9800	5	2.5	3.9	N.M.	N.M.
10-21 *	10,985	5	2.0	4.0	6.0	N.M.
10-21**	11,105	3	2.0	4.1	--	--
"	11,345	5	2.2	4.2	--	--

* 60 lbs fresh carbon added

** Influent Change

TABLE XXII

MEASUREMENT OF SUSPENDED SOLIDS (See Table II)

Type of Sample	Effluent Volume, Gallons	Suspended Solids, mg/l
Influent	0	280
Effluent	1980	220
Effluent	3770	220
Effluent	7355	164
Influent *	7680	200
Influent	8700	286
Effluent	9000	196

* Change in Influent

Work at Lindsay (Cont'd.)

TABLE XXIII

MEASUREMENT OF LIGHT TRANSMISSION AT 450 NANOMETER WAVELENGTH (See Table II)

Type of Sample	Effluent Volume, Gallons	Dilution Factor	Transmission, Percent
Influent	0	1 : 5	76
Port 1	270	None	62
Port 1	450	None	65
Port 2	450	None	63
Port 1	630	1 : 5	86
Port 2	630	None	67
Port 3	630	None	84
Effluent	630	None	75
Port 1	900	1 : 5	88
Port 2	990	None	79
Port 3	990	None	72
Effluent	1,260	None	92
Port 2	1,350	None	76
Port 3	1,350	None	86
Port 5	1,350	None	84
Port 1	1,980	1 : 5	83
Port 2	1,980	1 : 5	72
Port 3	1,980	None	52
Port 5	1,980	None	68
Port 3	2,880	None	62
Effluent	3,150	None	96
Effluent	3,410	None	92

TABLE XXIV

ANALYSIS OF SAMPLES COLLECTED AT SAMPLING PORTS - (Madera)

(See Table IV)

Date	Effluent Volume, Gallons	Port Number	pH	NaCl, Percent	C.O.D., mg/liter
4-14-69	160	1	4.5	4.8	17,200
		2	6.9	4.1	7,000
		3	*		
	280	1	4.1	4.8	20,800
		2	5.4	5.1	12,800
		3	*		
	400	1	4.0	4.5	22,800
		2	4.5	5.2	18,400
		3	*	5.6	16,480
	520	1	4.0	4.8	22,800
		2	4.5	5.2	18,400
		3	*	5.6	14,200
	640	1	3.9	4.5	23,000
		2	4.2	5.2	18,700
		3	*	5.5	16,800
	720	1	3.9	4.8	22.400
		2	4.1	5.3	18,200
		3	*	5.4	14,900
		4	*	5.3	18,700
	800	1	3.9	4.8	22,400
		2	4.0	5.3	18,900
		3	*	5.4	21,000
		4	*	5.4	16,300
	1080	1	3.8	6.3	36,400
		2	3.9	5.3	20,200
		3	*	5.4	18,100
		4	*	5.5	16,600

Work at Madera (Cont'd.)

ANALYSIS OF SAMPLES
COLLECTED AT SAMPLING PORTS (Cont'd.)

Date	Effluent Volume, Gallons	Port Number	pH	NaCl, Percent	C.O.D., mg/liter
4-14	1200	1	3.8	6.3	35,600
		2	3.9	5.3	19,200
		3	*	5.4	19,500
		4	*	6.6	18,600
4-15	1240	1	3.7	6.6	34,400
		2	3.7	6.5	27,200
		3	*	6.9	22,600
		4	*	6.9	22,600
	1360	1	3.7	6.3	36,600
		2	3.6	6.8	30,800
		3	*	6.9	26,700
		4	*	6.9	26,400
	1480	1	3.8	6.0	34,400
		2	3.6	6.0	31,600
		3	*	7.1	29,800
		4	*	6.9	21,300
	1600	1	3.8	6.0	34,400
		2	3.6	6.0	30,400
		3	*	6.9	27,000
	1880	1	3.7	6.3	22,600
		2	3.6	6.0	31,200
		3	*	7.1	26,600
		4	*	7.0	26,700
	2000	1	3.7	6.0	35,200
		2	3.6	6.8	32,400
		3	*	7.1	28,200
		4	*	7.1	27,700

* Little change from other values, not recorded.

Work at Madera (Cont'd.)

ANALYSIS OF SAMPLES COLLECTED AT SAMPLING PORTS

(See Table VI)

Date	Effluent Volume, Gallons	Sampling Port Number	pH	Total Acidity, g Lactic per 100 g	C.O.D., mg/liter
5-12	160	1	4.2	0.97	39,700
		2	4.2	0.96	36,300
		3	4.5	0.80	28,500
		4	4.7	0.53	28,500
		5	4.6	0.37	23,700
	400	1	4.1	1.08	40,300
		2	4.2	0.98	38,400
		3	4.3	1.00	30,900
		4	4.4	0.81	30,400
		5	4.8	0.67	28,000
	800	1	4.1	1.08	32,800
		2	4.1	1.05	40,500
		3	4.3	1.07	39,000
		4	4.2	1.03	34,700
		5	4.4	0.98	32,300
5-13	1040	1	4.0	1.50	35,000
		2	4.0	1.42	36,300
		3	4.2	1.48	35,000
		4	4.2	1.31	33,000
		5	4.1	1.03	31,700
	1160	1	4.0	1.50	38,700
		2	4.0	1.52	36,500
		3	4.2	1.50	32,800
		4	4.2	1.38	33,100
		5	4.2	1.50	31,200

TABLE XXV

SALOMETER READINGS ON EXPERIMENTAL OLIVE STORAGE BRINES

Tank Number	Salometer Reading on Date of Salt Additions									
	10-7 69	10-14 69	10-21 69	10-28 69	11-4 69	11-11 69	11-25 69	12-15 69	1-13 70	2-9 70
69-1-A	12	15	17	28	30	23	30	28	29	27
69-1-B	12	14	12	28	29	24	28	28	28	26
69-1-C	12	14.5	15	27.5	29	22	33	28	29	28
69-1-D	12	13.5	16	25	26	23	29	29	29	29
69-2-A	12	13	16	27	27	24	28	27	28	28
69-2-B	12	13.5	15.5	27	27	23	29	28	28	29
69-2-C	12	13	15	27	27	22	30	28	29	29
69-3-A	12	14	17.5	26.5	26.5	24	26	26	26	25
69-3-B	12	13	16.5	26	26	22	27	26	26	27
69-3-C	12	12.5	17	27	27	24	26	26	26	25

TABLE XXVI

IRON LEVEL IN
INFLUENT AND EFFLUENT SALT SOLUTIONS FROM
ACTIVATED CARBON TREATMENT OF STORAGE BRINE

Date of Sampling	Table VII Effluent Gallonage	Iron Concentration, ppm	
		Influent	Effluent
7-21-69	3030	9.90	16.17
7-25-69	6060	8.80	13.02
7-28-69	9615	9.86	8.42
8-5-69	17,355	14.87	11.87

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*Olive brines

27 Abstract

Storage brines and processing waters from the production of canned ripe olives and glass packed green olives were treated with activated carbon. The reuse potential of reconditioned brines was evaluated. Reconditioned storage brines can be used to store freshly harvested olives for commercially significant periods. Canned samples prepared from olives stored in reconditioned brine were of good quality. Reconditioned brines of lower salt content were reused with no detectable effect on the quality of the final product.

Estimates for commercial application of activated carbon treatment of storage brines show a cost per ton of olives stored of $3.64 when capital costs are amortized over 10 years for a cannery storing 5,000 tons of olives annually. Ten olive canneries reconditioning brine and sending spent carbon to a centrally located reactivation facility would have a cost of $1.28 per ton of olives stored.

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